Risk mitigation to minimize recalls in food supply chains (FSC): a literature review

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Abstract

Food supply chains are becoming increasingly vulnerable to risks that can cause product quality failures and, consequently, result in a recall incident. Since recalls are generally the result of multiple risks, it is necessary to use risk mitigation in order to minimize possible recalls in the food industry. The objective of this paper is to identify the risk mitigation actions which can minimize food recall occurrences. We used a systematic literature review with content analysis in this research. This study helps in identifying a set of 34 risk mitigation actions which can potentially avoid the occurrence of recall in FSC.

Keywords: Food recall, Food supply chain, Risk mitigation.

Introduction

Food supply chains (FSC) have become increasingly complex and global, with multiple tiers of suppliers and customers spread across the world (Chaudhuri et al, 2016). The food supply chains have some unique characteristics related to logistical efficiency, quality, safety and sustainability (Göbel et al., 2015) and also, seasonality in availability, variations in quality and perishability of the raw material and the final product, and seasonality of consumption (Batalha & Silva, 2007). These aspects make risk management difficult and, at times, negligence at any node of the supply chain can cause incidents that threaten food safety, resulting in recalls.

Recall is the act of requesting the return of a batch or the entire production of a commercial product due to a defect that could negatively affect consumer health or violate government regulations (Bernon et al., 2018; Potter et al., 2012). Recalls transcend industries and can have negative effects for intermediate and end customers in a chain due to the complexity of connections (Bernon et al., 2018). The negative effects can be the compromise of the performance of the operations (implying disruptions, stoppages in

production and distribution), the reduction of the brand value damaging the reputation, the losses of revenue and market share (Bernon et al., 2018), in addition to changing consumer demand and future market prices (Potter et al., 2012).

An opportunity to minimize and avoid food recall is through risk mitigation actions. Recalls are generally the result of multiple risks that propagate throughout the supply chain and it is necessary to develop proactive risk management plans to avoid or minimize the effects of recalls (Chaudhuri et al., 2016). Nakandala et al. (2017) highlight that risk mitigation actions in the food supply chain are used to ensure food safety. Indeed, ensuring food safety is the duty and responsibility of the actors involved in the chain (Storory et al., 2013). Therefore, the safety of food products can only be achieved through the joint efforts of all participants in the chain: feed producers, primary producers, food manufacturers, operators, subcontractors, transport and logistics operators, retailers and distributors, public authorities , media professionals, associations and consumers (Mattevi & Jones, 2016; Chammen et al., 2018).

Kumar & Budin (2006) identify control systems as a possible preventive measure to reduce recalls. In addition, Roth et al. (2008) indicate a quality management structure for the food supply chain that involves traceability, transparency, testability, time, trust and training as actions to preserve food safety. Potter et al. (2012) show that there is a trend for food recall in different countries and identify the most frequent types for different food products. Diabat et al. (2012) analyze the types of risks involved in a food supply chain. In the same sense, Chaudhuri et al. (2016) proposed a map of the propagate of multiple risks that affect suppliers in the processed food supply chain. Bamgboje-Ayodele et al. (2016) highlight that recovery from a food incident depends on many factors, including pre-existing brand reputation, effective information management, control mechanisms and response from supply chain partners. In this sense, Jonhson-Hall (2017) analyzes the factors that influence the corrective action subsequent to quality failures in the context of recalls of food products. Chammen et al. (2018) discuss food safety and differences in the regulatory framework of government food control agencies in different regions of the world. In summary, the studies carried out to date on recalls and risk mitigation actions in the food chain have outlined the impact of recalls in the supply chain. However, no study has explored how a set of risk mitigation actions can contribute to reducing recall incidents in FSC. Therefore, the purpose of this article is to identify the risk mitigation actions which can minimize food recall occurrences.

Research methodology: systematic literature review

Following Tranfield et al. (2003), the process of systematic literature review (SLR) began with the definition of the research question through a scope review on the themes of recall and risk mitigation in FSC. Then, the review questions were constructed (Table 1) followed by the SLR protocol in order to protect the objectivity of the research (Tranfield et al., 2003), in which the bases for this research were defined: EBSCO, ProQuest / ABI, Scopus, Web of Science and Scielo (capture national works in the studied theme). The search strings were built based on constructs and keywords (including synonyms and related words) and the search was carried out until September 2019, without limiting the starting date. The filters used for the selection were: 1) reading the title, abstract and keywords; 2) reading the introduction and conclusion; 3) full reading and evaluation of full papers.

Table 1 - SLR questions, keywords and strings

Questions	Keywords	Strings
1) What are the main causes of recalls in FSC?	Recall Food recall Food supply chain	((“supply chain*” OR “supply net*” OR “value chain*”) AND (“recall*” N5 (“food*”)))
2) What are the risk mitigation actions in FSC?	Risk mitigation Risk management Food supply chain	(((“supply chain*” OR “supply net*” OR “value chain*”) N5 (“food*”)) AND (“risk*” N5 (“mitigat*” OR “practic*” OR “management*” OR “reduc*” OR “diminish*” OR “minimiz*”)))
3) How do risk mitigation actions minimize the occurrence of food recalls?	Recall Food recall Risk mitigation Risk management	((“recall*” N5 (“food*”)) AND (“risk*” N5 (“mitigat*” OR “management*” OR “reduc*” OR “diminish*” OR “minimiz*” OR “practic*”)))

Inclusion and exclusion criteria were defined, according to (Tranfield et al., 2003): the articles must be written in English or Portuguese, be from scientific journals peer-reviewed and the concepts of recall and risk mitigation are in a context of operations management and / or supply chain management. After the filters, from 577 articles, 83 were selected and critically analyzed. The analysis and synthesis stage was performed based on the content analysis method according to Bringer (2006) and Krippendorff (2013). Content analysis is recommended to facilitate rigorous exploration of complex issues in the field of management (Duriau et al., 2007). The articles were distributed in 56 peer-reviewed journals between 2003 and September 2019, with the majority being published between 2012 and 2018 (72.2%). The main method used by the authors was the literature review (44%) followed by the case study (23%) and modeling (16%).

Main causes of recalls in food supply chains

Le Vallee & Charlebois (2015), food product recalls are a vital part of the food safety management infrastructure and responsiveness (Le Vallee & Charlebois, 2015). Recalls are the means by which the food industry and government regulatory bodies ensure food safety by removing food products from the entire supply chain, stocks, points of sale, store shelves and consumers (Le Vallee & Charlebois, 2015). A food recall is a request to return a batch or an entire production run of a product to the manufacturer, due to the find out of safety issues, to protect consumer health and ensure the safety of the FSC (Roth et al, 2008; Kumar, 2014). The recalls can be voluntary, carried out at the initiative of the manufacturer, or involuntary, imposed by a government agency (Kumar & Budin, 2006). The recall is a complex process that involves communication from several stakeholders, in addition to including the main documentation procedures (Kumar, 2014). In addition, the various layers of the supply chain, if not integrated, can add additional layers of complexity to the entire process (Kumar, 2014).

According to Kumar & Budin (2006), Le Vallee & Charlebois (2015) and Hall & Johnson-Hall (2017), the risk associated with the recall can be classified into three severity classes, where Class I recalls represent the level highest risk to human health. Class I recalls are associated with defective products that can cause serious injury, illness or death. Defective products that can cause temporary injury or illness are designated as Class II. Class III recalls are associated with defective products that are unlikely to cause injury or illness, but that violate food safety regulations. Class I and II recalls are urgent and very necessary, while Class III recall decisions may be based on concerns such as the brand image (Kumar & Budin, 2006).

Food product recalls can be a consequence of poor control of production conditions (for example, presence of microbial agents, chemical additives, incorrect processing and packaging), control of food quality attributes (for example, temperature, humidity, contamination) (Ringsberg, 2014) or for adulterations for economic reasons or terrorism (Lu & Koufteros, 2017) that compromise food safety and human health. According to Potter et al., (2012), Le Vallee and Charlebois (2015) and Johnson-Hall (2017), the causes of recalls can be classified into three major groups of risks: biological, operational and chemical. In the study by Potter et al. (2012), operational product recalls were the most frequent (55% of all recalls), followed by biological risks (36%) and chemical risks (9%). Table 2 presents the risk groups and main authors.

Table 2 - Causes of food recalls

Risk	Causes	Authors
Biological	Associated with products contaminated by bacteria (pathogens), biotoxins, molds and biological contaminations.	Kinsey et al. (2011); Potter et al. (2012); Johnson-Hall (2017); Whitworth et al. (2017).
Operational	It includes contamination in production, incorrect labels and packaging, malicious or economically motivated adulteration.	Potter et al. (2012); Bogadi et al. (2016); Do et al. (2018); Walker et al. (2018)
Chemical	It covers a variety of chemical risks, from dyes, drugs and medicines, irradiation, pesticides, heavy metals, dioxins and chemicals that are harmful to health.	Casey et al. (2010); Potter et al. (2012); Allata et al. (2017); Song & Zhuang (2017).

Food product recalls for biological hazards occur due to contamination of pathogens, fungi (biotoxins and mycotoxins), molds and biological contaminations (Potter et al., 2012; Manning & Soon, 2013; Allata et al., 2017; Whitworth et al., 2017; Johnson-hall, 2017). Pathogens are the most common type of biological risk, accounting for 96% of all food recalls due to biological causes, and only a small proportion of recalls have been attributed to biotoxins and mycotoxins, molds and biological contaminations (Potter et al., 2012).

Recalls of food products for operational causes is the most frequent type that corresponds to 55% of all recalls (Potter et al., 2012). Thus, Potter et al. (2012) suggest that more research is needed to investigate the causes and consequences of organizational failures, human errors, managerial mistakes, machine defects and technical failures. Food recalls for operational reasons include incorrect labels and packaging, contamination and production failures, and food fraud, economically motivated or terrorist (Potter et al., 2012; Kumar 2014; Bogadi et al., 2016; Do et al., 2018). Recalls for operational causes were dominated by two main operational risks, incorrect labeling/undeclared ingredients and contamination of production, which together account for 79% of all recalls for operational causes (Potter et al., 2012). Chemical recalls constitute the smallest proportion of total food recalls, but cover a wide variety of chemical risks, ranging from dyes, drugs and medicines, dioxins, irradiation, pesticides, heavy metals, to chemicals harmful to health, such as melamine and aromatic hydrocarbons (Potter et al., 2012). Examples of food incidents due to chemical causes are the recall of Sudan 1 dye in 2005 in the United Kingdom (Potter et al., 2012), and the outbreak of radioactive meat and other foods in Japan in 2011 (Le vallee & Charlebois, 2015). Contamination by drugs and medicines were responsible for 9% of all food recalls because of chemicals, especially veterinary drugs, drug residues, hormones, and antibiotics like Furazolidone, Nitrofurazone, Sulfonamides and Streptomycin (Potter et al., 2012). Contamination by

heavy metals, on the other hand, varies from the presence, above the limit, of arsenic, cadmium, mercury, chromium, cadmium to nickel in foods (Potter et al., 2012).

Risk mitigation actions in the food supply chain

A food safety risk can be defined as a "biological, chemical or physical agent in foods with the potential to cause an adverse health effect" (Manning and Soon, 2017). This paper chose to classify the risk mitigation actions in the food supply chain based on the risk categories proposed by Jüttner et al. (2003), Diabat et al. (2012) and Nakandala et al. (2017): internal risks, in the microenvironment and macroenvironment (Figure 1). Risks in the internal environment include risks within the company, such as process risk and control risk. Microenvironment risks are the possibility of unplanned events that interrupt the normal flow of goods, services and information within a supply chain; it is generally associated with risks between the focal firm and suppliers and/or customers. Finally, the risks in the macroenvironment are the risks caused by events outside the supply chain, such as natural disasters, diseases such as avian influenza and political events in the region (Jüttner et al. 2003; Diabat et al., 2012; Nakandala et al ., 2017).

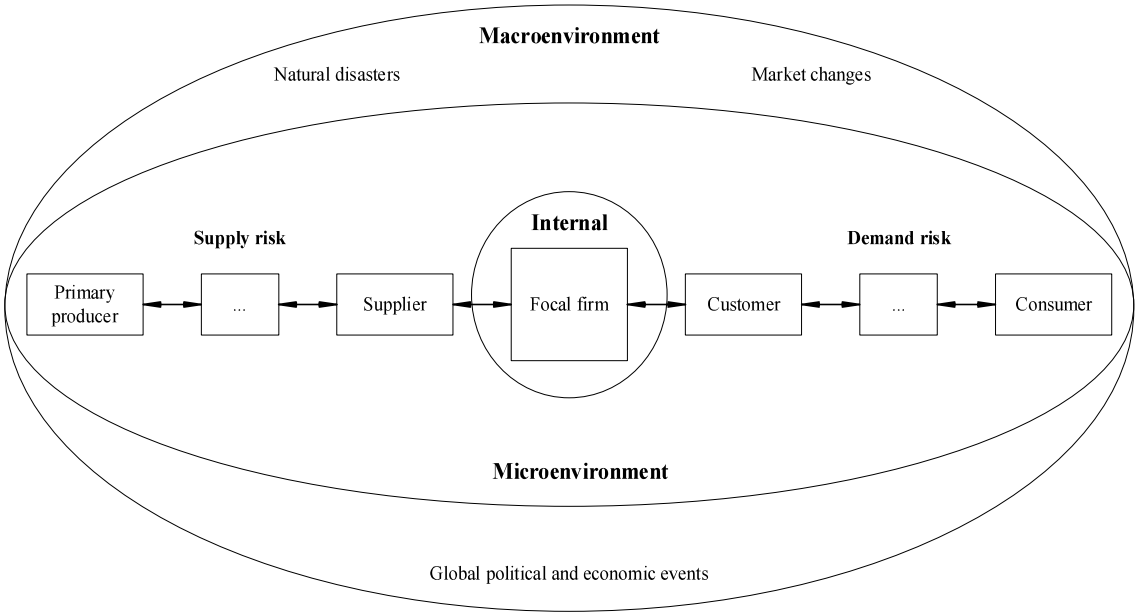

Figure 1 - Risk categories in the food supply chain. Source: Adapted from Jüttner et al. 2003; Diabat et al., 2012; Nakandala et al., 2017

Risk mitigation actions in the FSC are focused on preserving food safety (Nakandala et al., 2017). The mitigation of food safety risks requires infrastructure, such as food safety standards (public and private), laws, regulations and policies that facilitate food safety controls, inspections and oversight regular, effective emergency response mechanisms (traceability systems), import and export controls and monitoring of food safety risks (Le Vallee & Charlebois, 2015). In all, 34 risk mitigation actions were found in the food supply chain. Table 3 presents the risk categories, the mitigation actions corresponding to each category and the main revised authors.

Table 3 - Risk mitigation actions in the food supply chain

Category	Mitigation actions	Main authors
Macroenvironment	Government inspection and oversight; Government laws; Food defence; Resilience to natural disasters; International standards; Notification from regulatory bodies.	Ali et al. (2018); Bogadi et al. (2016); Baines et al. (2018); Chammen et al. (2018)
Microenvironment	Supplier audit; Standardization certifications; Storage control; Transport control; Traceability; Financial penalties for suppliers; Transparency and visibility; HACCP.	Aung & Chang (2014); Ringsberg (2014); Gianni et al. (2016); Allata et al. (2017)
Internal	Sampling and testing; Pre-harvest control; Post-harvest; Packaging and labeling control; Processing control; Internal traceability; Response time; Employee training; Hygiene control; Communication of recall events; Sizing of manufacturing lots; Batch dispersion for customers; Control on product receipt; Heat treatment; Financial; resource; Control of allergens; Information technology; Vaccination control; Control in commercialization.	Dodd & Powell (2009); Anne-Marie Donnelly et al. (2012); Shinbaum et al. (2016); Allata et al. (2017); Manning & Soon (2017); Baines et al. (2018); Walker et al. (2018)

Risk mitigation actions in food recalls

With the aid of the QDA Miner, a co-occurrence analysis was carried out relating the risk mitigation actions and the three categories of food recalls. The co-occurrence analysis considers the information regarding the proximity of the codifications, enabling the location of relationships between codes or between cases (QDA Miner, 2020). This allowed us to better understand the groupings and potential relationships of the causes of food recalls and risk mitigation actions. Figure 2 presents the framework for this co-occurrence analysis. To avoid bias in specific papers, the analysis was performed by comparing the number of cases in which at least one co-occurrence of the codes appears, if the relation is used more than once in the same case, it was counted only once. It is highlighted in Figure 2 that the bigger the bubble, the higher the rate of articles that address the relationship between the cause of recall and risk mitigation actions.

The results of the framework show that the actions with the highest indexes in the three recall categories are: government inspection and oversight, government laws, traceability, transparency and visibility, HACCP, employee training and communication of recall events. In fact, these are actions that can be used in the FSC to mitigate the risks involved in all recall categories. It is noted that recalls due to biological causes have the highest indexes of risk mitigation actions, indicating that this theme is being constantly addressed in the literature. In this category, specific actions in pre-harvest control, transport control, storage control, quality certification and hygiene control stand out as the most present to mitigate biological risks.

In relation to recalls for operational causes, the actions of allergen control, packaging and labeling control and food defence stand out. The analysis corresponds to the literature, since, recalls due to operational causes can occur due to cross contamination of allergens in production, labels and packaging do not comply with the laws and regulations in the market or recalls due to intentional actions, economically motivated or malicious (Potter et al., 2012). The results also indicate that recalls due to chemical causes have a lag in the literature on actions necessary to mitigate these risks compared to the other two categories. This may be the result of the scarcity of material in the literature on recall for chemical causes and/or, according to Potter et al. (2012), due to few occurrences in fact.

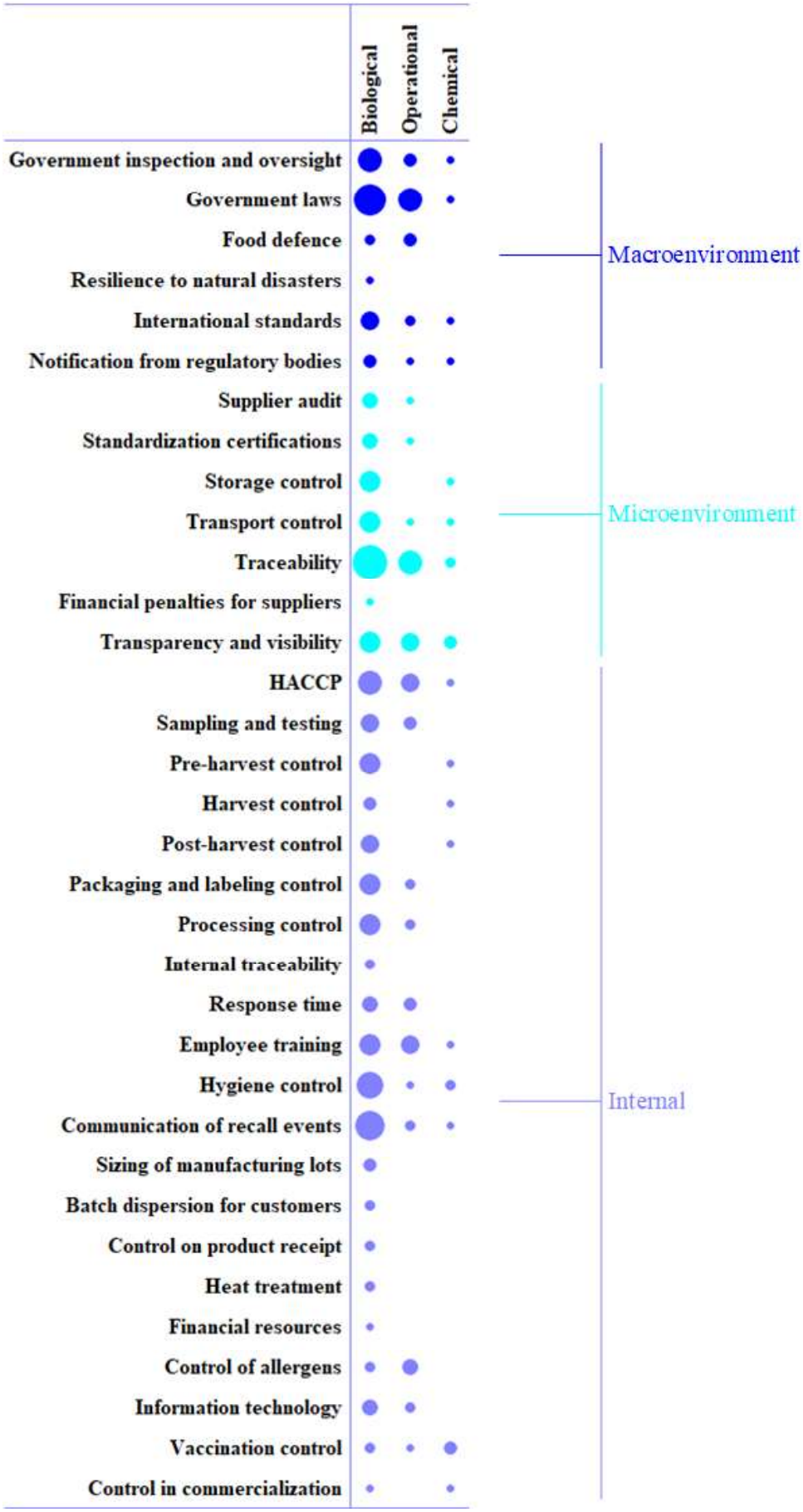

Figure 2 - Framework for the relation between risk mitigation actions and food recall

Conclusion

The results of this paper contribute to the ongoing investigations on recall and risk mitigation in a context of the food supply chain by providing a systematic literature review of 83 articles. The biological cause is the category that is related to the maximum risk mitigation actions in the literature, followed by the operational one and a small portion is turned to the category of chemical causes. Our results add to the literature when developing a framework listing the most suitable measures to mitigate the risks of a certain recall category of food products (Figure 2). Our results can help professionals and entities to understand and apply the appropriate mitigation measures to avoid or minimize the impacts of different types of food recall in FSC.

Although careful measures were applied to maintain the rigor of the research, there are limitations in this paper that need to be addressed for future implications. First, this research developed a theoretical framework for an FSC in general, specific characteristics of different segments of the food industry, such as dairy products, meat, fruits, vegetables and condiments, may present specificities that require different actions at multiple levels supply chain. For this reason, future research may apply in empirical research the model developed in different segments of the food industry to verify differences and similarities in each segment. Second, the results show a shortage in the literature on recalls for chemical causes and specific actions to mitigate this risk, compared with the other two categories of recalls. Additional research can be developed to fill this gap, such as actions to mitigate heavy metals and levels of anabolic and hormones present in food products.

Finally, recall events are threats that are present in other supply chains, such as automotive, pharmaceutical, toys and electronics (Bernon et al., 2018). The results present in this paper can provide bases and insights for the elaboration of future studies. Therefore, this paper urges researchers to investigate similarities and differences in the risk mitigation actions involved in a recall event in other supply chains.

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